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The risky business of keeping pigs during periods of climatic fluctuation: A case from the Mid-Holocene Near East

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ABSTRACT

The climate record of the Mid-Holocene southern Levant indicates a period of rapid climate change and erratic rainfall. An unpredictable rainfall regime would have posed a considerable risk to societies dependent upon crops and livestock that require a plentiful and consistent supply of water. In this paper, we first examine an assemblage of pig remains from Hartuv, a small settlement occupied during the Early Bronze Age, and then interpret these data alongside palaeohydrological evidence. We reconcile seemingly contradictory data—high relative taxonomic abundance of pigs and climatic conditions characterized by a general aridification trend and rainfall instability—by considering zooarchaeological assemblages from nearby sites in the context of their hydrological settings. On the basis of geoarchaeological evidence from Hartuv, we conclude that the effects of variable rainfall were mitigated by a locally marshy environment and an anthropogenic landscape feature, which may have been used to store water.

1. Introduction

Palaeoclimatic records of the Near East show that the late fourth millennium BC was characterized by high degree of short-term variability in rainfall (Bar-Matthews and Ayalon, 2004; Clarke et al., 2016). The effects of unpredictable precipitation on prehistoric agriculture are well known, but their effects on prehistoric livestock husbandry are not as well established. While sheep, goat and cattle are fairly tolerant of moderate vacillations between humid and arid conditions, pigs require a plentiful and dependable source of water in order to thrive (Burrin, 2001). It is for this reason that a high relative frequency of pig remains in a faunal assemblage is commonly taken as a corollary of humid environmental conditions.

In this paper, we seek an understanding of the impact of rapid climate change on local livestock management. The faunal assemblage from Hartuv, a Late Early Bronze I (middle to late 4th millennium BC) village site in central Israel, provides a sample of pig remains that is unusually abundant relative to most other assemblages from temperate regions of the southern Levant (Fig. 1). We explain how pigs thrived in this hydrologically unpredictable setting by examining three lines of related evidence: (1) inter-assemblage taxonomic differences in light of their ecological settings; (2) rapid climate change in the Middle Holocene; and (3) local hydrology and anthropogenic landscape features. While climate change is conventionally examined at global and continental scales, the zooarchaeological and geoarchaeological evidence from Hartuv provides an opportunity to understand how a local community overcame climatic uncertainty to maintain the Near Eastern tradition of keeping pigs.

2. Hartuv

Hartuv was excavated by A. Mazar and P. de Miroschedji over the course of three brief seasons in 1985, 1986 and 1988. Hartuv is located on the west bank of Nahal Soreq at the point in the river where the narrow gorge widens as it opens into the Shephelah. The site covers an area of about three hectares, but its ancient delineation is not clear. Strata II and III are attributed to an early phase of Late EB I by its pottery assemblage (Mazar and de Miroschedji, 1996). In the regional chronology, this pottery assemblage is most closely associated with Tel Erani C (Braun, 1996: 242, Table VII.A/2) and Horvat Ptora (Milevski and Baumgarten, 2008). Its location at the intersection of several natural roads provided easy access from the coastal plain to the west and hill country to the east, and from the northern and southern Shephelah. Hartuv is predominantly defined by a large, centrally located building complex presumed to have served communal needs of the village. Of the entire 600 m^2 area of the hillock on which this structure was built, 350 m^2 were excavated (Area A). An additional 65 m^2 were uncovered from an area of domestic architectural installations (Area B) on a

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Fig. 1. Map of the southern Levant showing the location of Hartuv and other EB sites.

smaller hillock to the south-west of Area A (Fig. 2).

The public building in Area A, which was thought to have occupied the entire hill-top, is defined by two large broad halls perpendicular to each other, two long, narrow rooms, a paved street or open space, and two small rooms with paved floors (Mazar and de Miroschedji, 1996: 5). The broad hall of this structure is reminiscent of the Late EB I temple at Megiddo (Shrine 4050, Chicago Stratum XIX/Tel Aviv Level J-3) (Finkelstein and Ussishkin, 2000) and to EB II-III temples at Ai and Yarmuth (Callaway, 1972; de Miroschedji, 1999). The public building at Hartuv was tentatively interpreted as a multi-functional building that was used for religious, social and political purposes (Mazar and de Miroschedji, 1996: 13). Lending to the interpretation of religious function of the Hartuv building was a row of worked, standing stone slabs (orthostats) along the inner face of a wall in Hall 152, a type of installation that no other EB building was known to have possessed at the time.

However, recent excavations at Horvat Ptora (North) uncovered six large buildings with architectural plans comparable to that of the public building at Hartuv and an associated pottery assemblage analogous to that of Tel Erani Stratum C (Milevski and Baumgarten, 2008). Of these six buildings, Buildings 4000 and 6000 have rows of worked, standing stone slabs lining the inner walls of their broad rooms. In light of the discovery of multiple large structures at a single settlement, some with standing stone installations, we are prompted to reconsider the significance of the building complex uncovered in Area A at Hartuv.

Of particular interest at Hartuv is the excavators' report of traces of ashes and burnt animal bones in the south-west corner of the public building's large, broad hall (Hall 152), a room that is thought to have served as a sanctuary (Mazar and de Miroschedji, 1996: 9). Burnt animal remains from a public structure have also been reported from Khirbet ez-Zeraqon (Genz, 2010) and vast quantities of animal remains were recovered from the temple complex at Megiddo (Level J-4, Late EB I) (Wapnish and Hesse, 2000).

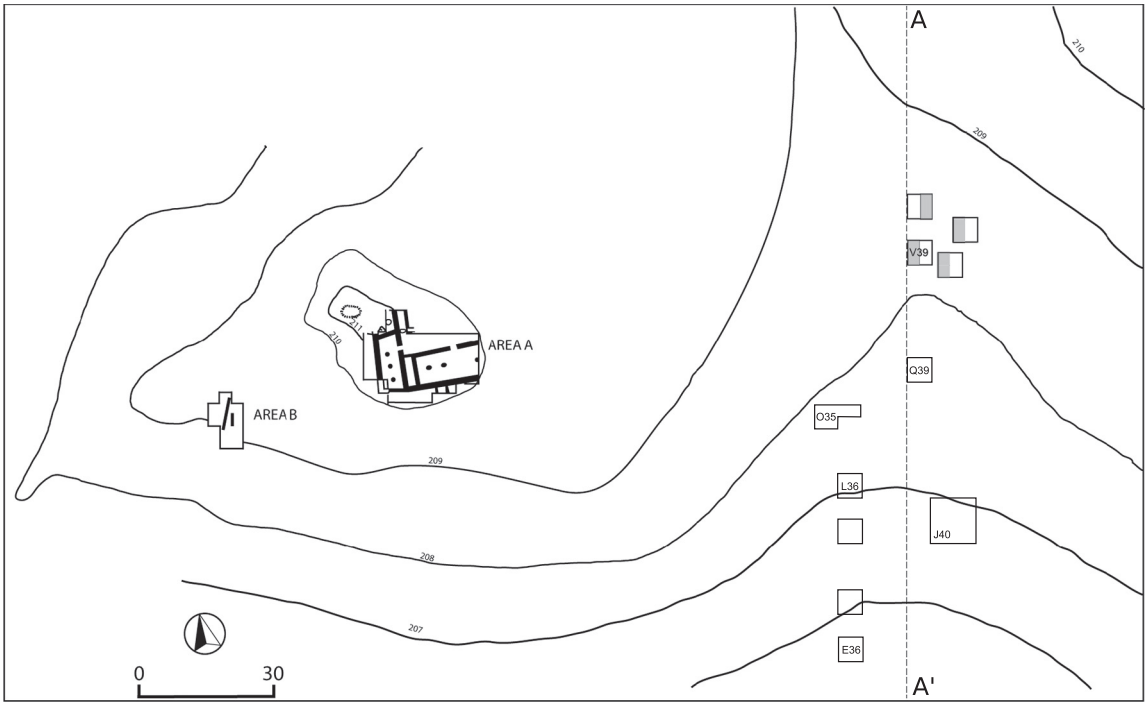

Fig. 2. Map of Hartuv and vicinity showing excavation Areas A and B, and location of geological sections and transect (A–A′).

3. Materials and methods

Faunal remains were recovered from all strata from Areas A and B. Stratigraphic correspondence between the two excavation areas was not found. However, with the exception of stratum A-1, all strata are ascribed to the late EB I period (i.e., 'Erani C Horizon'). Given their common chrono-cultural associations and the small size of the faunal sample, the faunal assemblages from Areas A and B are treated as a single late EB I sample in order to maximize the statistical potential of this analysis.

All animal remains recovered from Late EB I strata are considered in this analysis. Animal bones were collected by hand. Sieving was limited. Size-mediated recovery bias that suppresses the relative abundance of small fauna, such as rodents and birds, is almost certain given the limited quantity of recovered small animal remains (Table 1). However, only the smallest anatomical elements of medium- and large-sized animals, would have been differentially impacted by this factor.

The faunal assemblage was identified in 2009 at the Archaeozoology Laboratory at the Hebrew University of Jerusalem, Givat Ram, which is also the repository of the material and data. Faunal specimens were washed in water to remove soil. If calcium carbonate remained following this treatment, bones were immersed in a dilute acetic acid solution.

Taxonomic abundance was estimated according to the number of identified specimens per taxon (NISP) and the number of diagnostic zones per taxon (DZ). With respect to NISP, a specimen is considered 'identified' if it is recorded to at least the taxonomic family level. NISP, a simple, direct method of tallying identified specimens, although additive and often appropriate for ordinal scale statistics, suffers from the potential pitfalls of specimen interdependence (Lyman, 2008). DZ was recorded according to modified templates of Dobney and Rielly (1988) and calculated following Watson (1979). This technique divides each skeletal element into zones according to diagnostic features and the lines along which an element tends to fracture. A zone is recorded only if > 50% of that zone is preserved. Tallying for diagnostic zones partially obviates the problem of differential intertaxonomic identifiability because every mammalian species is accorded the same diagnostic zone templates. This is achieved by omitting horn cores, antlers, peripheral metapodials, clavicles and other skeletal elements that are only found in some mammalian skeletons. However, a caveat of the DZ measure is its tendency to underrepresent taxa that are characterized by high frequencies of fragments that are smaller than 50% of a diagnostic zone.

Minimum estimates of taxonomic abundance, such as MNI, are not attempted. Although derived measures of abundance are standard practice in zooarchaeological reports, the small size of the Hartuv faunal sample and the great likelihood of underrepresenting even the most frequently occurring taxa precludes minimum estimates.

Table 1
Frequencies and proportions of animal taxa at Hartuv.

	Taxon	NISP	%	DZ	%
Identified	*Spalax ehrenbergi**	1	0.4	–	–
	Canis sp.	1	0.4	0.2	0.1
	Felis sp.	1	0.4	0.2	0.1
	Equus sp.	5	2.2	2	0.6
	Sus scrofa	61	26.9	101.3	31.2
	Capreolus capreolus	1	0.4	1	0.3
	Dama/Cervus	1	0.4	0	0
	Gazella gazella	8	3.5	12	3.7
	Bos taurus	25	11	21	6.5
	Capra ibex	1	0.4	2	0.6
	Capra hircus	17	7.5	37	11.4
	Ovis aries	13	5.7	29	8.9
	Ovis/Capra	85	37.4	119.5	36.7
	Testudo graeca	7	3.1	0	0
Unidentified	Medium carnivore	1		0	
	Large mammal	48		1	
	Medium mammal	169		7	
	Small mammal	5		4	
	Mammal	62		0	
	Large Falconiformes	1		14	
	Large Aves	1		0	
	Medium Aves	1		0	
	Small Serpentes	1		0	
NISP (based on Family or greater)		227	100	325.2	100
TNF (NISP + Unidentified)		516		351.2	

* The complete skeleton of a mole rate counted as a single specimen for NISP and omitted from DZ count.

The principal analytical categories that were recorded are taxon, anatomical element, diagnostic zone(s), fragment size, side, state of fusion, degree of weathering, butchery traces, gnawing, burning, and pathology. Too few skeletal elements were sufficiently complete to permit osteometric inferences of sex and status of domestication. Age at death was determined on the basis of epiphyseal fusion and dental data (Bull and Payne, 1982).

Statistical significance was tested at the 95% confidence level ($p = 0.05$).

4. Results

Excavation of Hartuv yielded a small assemblage of 227 identified remains (NISP). The small size of the sample is largely attributed to limited excavations over three brief seasons. Table 1 presents the abundance and relative proportions of animal taxa from the Hartuv assemblage. Of the 516 bone and tooth fragments recovered from the excavations, 44% were identified to at least a taxonomic family. With respect to taxonomic richness, twelve genera were identified. Sheep (*Ovis*) and goats (*Capra*) are the most abundant taxa based on both NISP and DZ. Pig (*Sus scrofa*) is the next most abundant taxon, which is followed by cattle (*Bos taurus*). These four animal categories constitute the major taxa. Other identified taxa, each accounting for < 4% of the identified assemblage according to both measures of abundance, include *Equus* sp., *Dama/Cervus*, *Capreolus capreolus*, *Gazella gazella*, *Canis* sp., *Felis* sp., *Spalax ehrenbergi*, and *Testudo graeca*.

Although the taxonomic abundance estimates that NISP and DZ yield are often different depending on the nature of fragmentation for a given taxon, both measures describe very similar intertaxonomic relationships in the Hartuv sample. In terms of rank-order, there is a positive and highly significant correlation between NISP and DZ ($r_s = 0.934, p < 0.001$). In fact, both measures rank the most abundant taxa identically. It is only the least abundant taxa that DZ underrepresents relative to NISP. Therefore, it is reasonable to conclude that NISP and DZ are redundant for abundant taxa, but not for rare taxa and others that may only be represented by teeth and cranial elements that DZ ignores.

Pigs are abundant at Hartuv according to both NISP (26.9%) and DZ (31.2%). Fig. 3 shows the distribution of pig skeletal parts based on the relative frequencies of DZs. All long bone parts, except for the low-density proximal humerus, are represented. Small, compact bones such as carpals, tarsals and sesamoids are missing from the assemblage, which is likely a function of size-related recovery bias. Scapulae are significantly overrepresented relative to all other skeletal parts. Of the seven scapula specimens, five are from Locus 220 in Area B. Unfortunately, this locus derives from a probe excavation from which contextual information is unavailable.

The culling pattern of pigs based on epiphyseal fusion (Fig. 4) indicates that animals under two years of age succumbed to a high rate of mortality. In fact, the fusion data offer no indication that any pigs survived beyond the second year of life. Likewise, the mandibular dental data, albeit scant ($n = 4$), do not reflect any animals older than two years of age. Evidence for neonatal and infantile pig mortality is found in two cases: an unfused diaphysis of a femur and a mandible fragment containing a deciduous 3rd molar. This pattern of early culling agrees with a standard pork exploitation strategy in which almost all pigs are culled after the weaning period but before the birth of the next litter (Redding, 1991: 23).

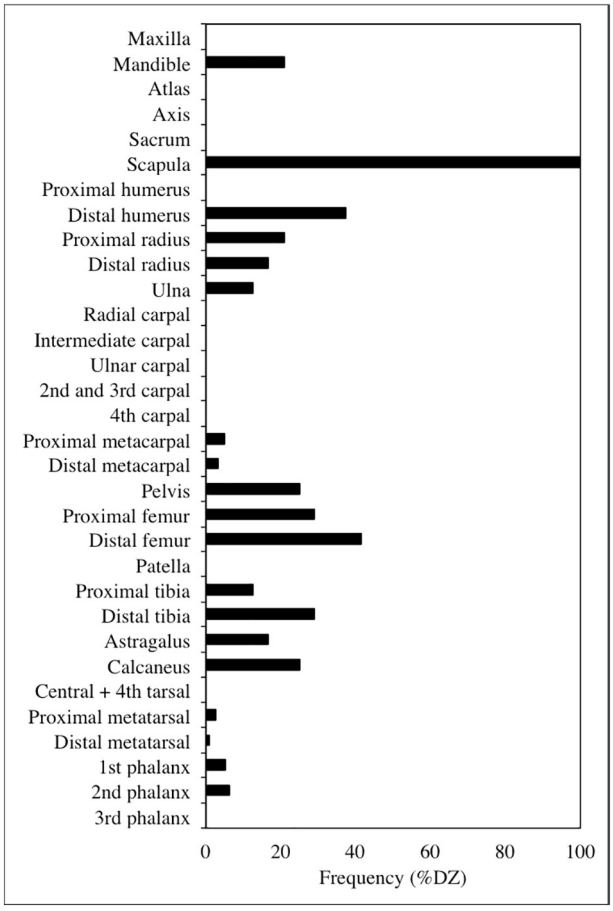

Fig. 3. Pig skeletal parts as a proportion of the expected number of intact skeletons ($n = 12$) based on diagnostic zones (DZ).

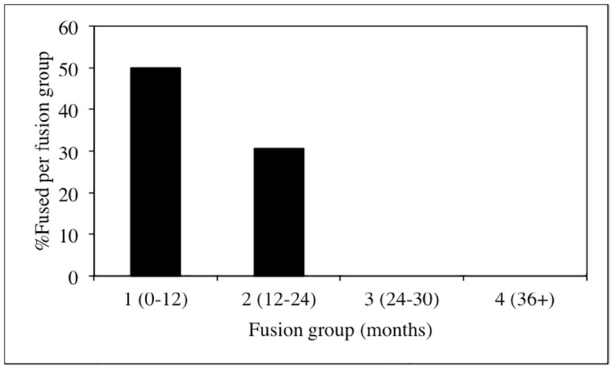

Fig. 4. Pig age distribution based on epiphyseal fusion classes ($n = 26$).

5. Discussion

The modest faunal assemblage from Hartuv is, in most respects, typical of its chronocultural context. However, the prominent representation of pigs—30% of faunal remains from livestock species—is remarkable given their paucity in most other EBA assemblages from the Shephelah. In order to explain this deviation from the trend, three strands of data that pertain to the environmental context of Hartuv are offered: (1) inter-assemblage taxonomic differences in light of their geographical contexts; (2) rapid climate change in the Middle Holocene; and (3) local hydrology and anthropogenic landscape features.

5.1. Regional comparisons

The limited array of animal species that were exploited at Hartuv is typical of Early Bronze Age (EBA) settlements in the southern Levant (Grigson, 1995; Hesse and Wapnish, 2002). However, the proportional differences among the various taxa are unusual in the context of neighbouring EB I and EB II sites in the Shephelah. In particular, the

Table 2
Frequencies of livestock from sites discussed in the text ordered according to proportion of pigs. Following Grigson (2007: 84), the relative abundance of a taxon is calculated as the percentage of that taxon's NISP against the total livestock NISP (sheep + goats + cattle + pigs).

Site (period)	Sheep/goat		Cattle		Pig		Total livestock	Total NISP	Reference
	NISP	%	NISP	%	NISP	%			
Hartuv (Late EB I)	115	57.2	25	12.4	61	30.3	201	227	
Tel es-Sakan (EB I)	60	58.8	17	16.7	25	24.5	102	117	de Miroschedji et al. (2001)
Tel Erani (EB II)	421	64.8	158	24.3	71	10.9	650	787	Ducos (1968)
Tell Halif (EB I)	3562	90.2	257	6.5	128	3.2	3947	4291	Zeder (1998)
Tel es-Sakan (EB III)	436	73.0	151	25.3	10	1.7	597	641	de Miroschedji et al. (2001)
Halif Terrace (Late EB IB)	3038	84.4	503	14.0	59	1.6	3600	4125	Kansa et al. (2006)
Halif Terrace (Early EB IB)	313	83.2	60	16.0	3	0.8	376	420	Kansa et al. (2006)
Tel Dalit (Late EB I)	176	83.8	33	15.7	1	0.5	210	228	Horwitz et al. (1996)
Tel Yarmuth (EB II)	662	85.1	116	14.9	0	0.0	778	787	Davis (1988, n.d.)

prominence of pigs at Hartuv stands in contrast to their complete absence at neighbouring Tel Yarmuth (Davis, 1988, n.d.), and near-absence at sites farther afield, such as Tel Dalit at the northern Shephelah/coastal plain boundary (Horwitz et al., 1996), and Tell Halif (Zeder, 1998) and Halif Terrace (Kansa et al., 2006) in the southern Shephelah where it meets the northern Negev (Table 2). In fact, only one other site in the vicinity, Tel Erani, has yielded a substantial proportion (> 10% NISP) of pig remains (Ducos, 1968).

An unresolved debate addresses the demise of pigs in post-Chalcolithic faunal assemblages and its linkages to climatic deterioration, geographically variable ecological constraints, agricultural intensification, and urban expansion (e.g., Grigson, 1995, 2007; Hesse, 1995; Zeder, 1998). Relatively little scholarly attention has been given to the inverse phenomenon of settlements that have maintained the Neolithic-Chalcolithic tradition of rearing pigs as a critical component of their subsistence base (Marom and Bar-Oz, 2013). Grigson's (1995) broad survey of animal husbandry practices from the Late Neolithic to the Iron in the southern Levant estimates that pigs provided up to 15% of the meat to communities before the EBA. EB I sites in southern Israel, such as Hartuv, Tel Erani (Ducos, 1968), and Tell es-Sakan (de Miroschedji et al., 2001), surrounded by settlements devoid of pigs, represent places in which pig-keeping persisted.

A rare view into a local diachronic shift in pig bone abundance is provided at Tell es-Sakan, a coastal plain site where pigs account for about 24% of the animal remains in Late EB I, but plummet to < 2% by EB III. This dramatic reduction has been explained as stemming from a demographic shift in ethnicity wherein an overwhelming Egyptian presence in the former period was replaced by a Levantine population by the latter period (de Miroschedji et al., 2001: 96–97). In this particular case, climatic aridification does not appear to have instigated the disfavour of pigs in EB III as the remains of the river-dwelling hippopotamus attest to adequate hydrological conditions at this time.

The importance of pigs in the local subsistence economy of Hartuv is unusual when considered in the broader regional context of other EBA settlements with shared geographical, ecological and political characteristics. In this sense, the abundance of pig remains in the faunal assemblages of Hartuv and Tel Erani is exceptional; these exceptions to the rule are potentially just as interesting as the rule itself, and therefore merit exploration. One possible explanation for the high frequency of pig remains at Hartuv may relate to the function of the large public building in Area A. The pig's rapid growth rate and high meat yield make this animal ideally suited to feed many people in communal feasting events. However, there is no faunal data to support an assertion of ritual exchange, let alone this building's function as public. In fact, the concentration of five pig scapulae is not associated with the public building in Area A, but rather with the domestic complex in Area B. As they were at the outset of this paper, the burnt animal bones from the south-west corner of the public building's broad hall remain the only, albeit tenuous, potential trace of ritual use of animals at Hartuv.

Grigson's (2007) zooarchaeological survey of pig exploitation in the southern Levant clearly demonstrates broad spatial patterns of pig representation in well-watered regions of the North and a relative paucity of pigs in the arid South. She finds that the geographical demarcation on which pig rearing is divided roughly falls along the 300-mm isohyet, which she associates with limit of rain-fed farming. Emerging from this work is an understanding of a general spatial pattern in which EBA sites with significant proportions of pig remains are located in the Mediterranean littoral and in the northern part of the country between the coast and the lush Jordan Valley. In this regard, the prominence of pigs at Hartuv accords with well-watered EBA sites along the coastal plain such as Azor (Horwitz, 1999), Lod (van den Brink et al., 2015), Afridar (Area G) (Kansa, 2004) and Tell es-Sakan (de Miroschedji et al., 2001), and in the Galilee and northern Jordan Valley such as En Shadud (Horwitz, 1985), Tell esh-Shuna North (Croft, 1994).

5.2. Mid-Holocene climatic uncertainty

The climatic conditions of the Holocene Levant are now coming into focus, with dozens of environmental proxies from Near Eastern localities forming a rich dataset. These proxies generally agree that the Near East was humid and relatively stable in the early Holocene, then trended toward aridification and instability, with periods of rapid and severe climate change in the middle Holocene (Mayewski et al., 2004; Brooks, 2012; Clarke et al., 2016). Reconstructions based on Levantine climate proxies from the Soreq Cave and Jeita Cave demonstrate that the 4th millennium BC experienced increasing aridity and a succession of rainfall fluctuation events (Verheyden et al., 2008; Bar-Matthews and Ayalon, 2011; Clarke et al., 2016). Records gathered from sediment cores from the Dead Sea shore do not show clear directionality of climate change during the 4th millennium, but decadal rainfall fluctuations that parallel other climate records from the region are evident (Migowski et al., 2006).

The high-resolution record from the Soreq Cave is particularly relevant, as it is located in close proximity to Hartuv and therefore represents local environmental evidence. According to oxygen ($\delta^{18}O$) and carbon ($\delta^{13}C$) isotope data from the Soreq Cave's calcite stalagmite deposits (speleothems), these fluctuations are particularly dramatic in EB I (~5.1–5.6 kyr BP) as they alternate between wet and dry episodes over a short period (Bar-Matthews and Ayalon, 2004: 382, Fig. 12). Furthermore, a prominent increase in $\delta^{18}O$ at 5.2 kyr BP, which is approximately coeval with the EB I occupation of Hartuv, signals a period of reduced rainfall that lasted no more than a century (Zanchetta et al., 2014). Annual rainfall for the end of the Chalcolithic to beginning of the EB I, although variable, is estimated to have been ~350 mm (Bar-Matthews and Ayalon, 2011: 168). Zanchetta et al. (2014: 134) determine that the amount of annual rainfall sharply decreased by 280 mm over the short interval of 5.8 to 5.6 kyr BP (~early EB I). This is significant given that the minimum annual rainfall that pigs in the ancient Near East needed to thrive was around 350 mm (Grigson, 2007: 108). Therefore, the frequent and dramatic rainfall changes witnessed

in the EBA would have surely made for a hydrologically unreliable landscape on which raise pigs.

Stochastic rainfall would have made pig-keeping a risky endeavor, as swine do not survive if not adequately hydrated. Avoiding this risk in an uncertain environment would have been a matter of employing any number of strategies that reduce pigs' exposure to environmental hazards (i.e., drought and heat exposure). These buffering strategies may include shifting to a more diversified allocation of livestock species and non-pastoral subsistence staples; exchanging livestock for non-livestock with neighbouring communities; moving livestock to more suitable pastures or more dependable water supplies; or storage, which may be achieved by accumulating a large herd as a buffer against future losses (Halstead and O'Shea, 1989). The storage strategy, however, may have been employed, not by accumulating pigs, but rather by accumulating quantities of water necessary for hydrating pigs.

5.3. Local hydrology

The increasingly arid and erratic rainfall conditions of the 4th millennium BC would have been especially felt in the Shephelah, a high, inland plateau that connects the coastal plain to the west and the Judean highlands to the east. The poor representation of pigs in faunal assemblages from EBA sites that share similar landscapes agrees with this environmental evidence. The question remains, why did pigs persist at Hartuv and not at nearby communities?

Despite this general pattern, there is one other notable exception of a site with substantial pig remains located in an inland region in the southern Levant. Alongside Hartuv, with 30% of its livestock remains represented by pigs, is Tel Erani, which produced a livestock assemblage for which pig bones comprised 11%. In fact, the ecological settings of these two sites have much in common. At Tel Erani, gravel deposits dated to the Chalcolithic and EBA suggest a steady stream flow likely due to increased and sustained precipitation during the rainy season. Thick deposits of fine-grained silts and clays reflect levee and backswamp deposits from a perennial stream. Furthermore, some sediment sections at Tel Erani contained heavy, dark clays indicative of seasonal marshy deposits (Rosen, 2007).

At Hartuv, similar dark clay marsh deposits contemporaneous with the EB I village were identified in sections immediately east of the site (Fig. 2). These floodplain soil deposits suggest that the flow of the Nahal Soreq was so high that floodwaters inundated low-lying areas surrounding Hartuv for much of the year (Fig. 5). In fact, these marshy conditions may have motivated the initial settlers of Hartuv to occupy the high ground of the two hillocks on which the architectural features are located. Geological evidence also indicates at least one major flood episode of the Nahal Soreq, an event that spread channel gravels at higher elevations. These gravels were deposited with EB I sherds in a matrix of silty clays. Another, perhaps related, feature is an anthropogenic trench or depression immediately east of site. Its function is not clear, but it may have served as a pond for water storage or drainage. If this anthropogenic feature was indeed used for storing or diverting water and, moreover, for buffering the effects of unreliable precipitation, then the important role that pigs appear to have played in the subsistence economy of Hartuv makes good sense.

The swampy conditions that surrounded Hartuv would have made agricultural production a difficult enterprise. Furthermore, a low frequency of cattle remains and a marginal presence of equids does not provide strong evidence that animal traction was adopted at Hartuv, although it was an emerging technology for mobilizing agricultural supplies and harvests at other EBA settlements. Nevertheless, strong evidence for agricultural harvesting technology exists at the site. Sickle tools, which are conventionally associated with crop-harvesting, constitute one-third of the chipped stone assemblage (Rosen, 1996). From these seemingly contradictory lines of evidence, it stands to reason that agricultural fields must have been located beyond Hartuv's swampy catchment, but sufficiently close to the settlement that at least some of the sickle blades used for harvesting crops were stored or discarded at the site. Pigs, on the other hand, could have been left to drink and wallow in the swampy surrounds of the village. If this model—keeping pigs close to home and agricultural fields at a distance—holds true, then agricultural production would not have been hindered by the practice of keeping pigs, which are notoriously voracious crop consumers.

6. Conclusions

The villagers of Hartuv relied on a livestock subsistence base similar in many respects to that of other EBA settlements of the southern Levant. Domesticated sheep, goats, pigs and cattle constituted the staple dietary resource animals. Wild animals such as gazelles and deer played only minor roles and were apparently not required to subsidize the domestic stock. Although this limited array of animal taxa may be a partial product of sample size, the assemblage is thought to reflect dependence on a limited range of domestic stock. However limited, the fact that the assemblage is composed of sheep, goat, pig, cattle, and several wild game taxa may signal a cultural strategy of risk-buffering against climatic variability. Maintaining a food supply of composed of animals whose nutritional and environmental requirements are diverse (and a similarly broad plant base) can be an effective risk management strategy against the impact of food shortages (Halstead and O'Shea, 1989).

Sheep and goat together constitute the most abundant animal category at Hartuv. Pigs appear to have played a secondary but substantial role in the local subsistence economy on the basis of relative taxonomic abundance. Sustainable pig-keeping requires a plentiful and dependable water source because swine have high water requirements relative to sheep, goats and cattle. Pigs do not have the ability to sweat.

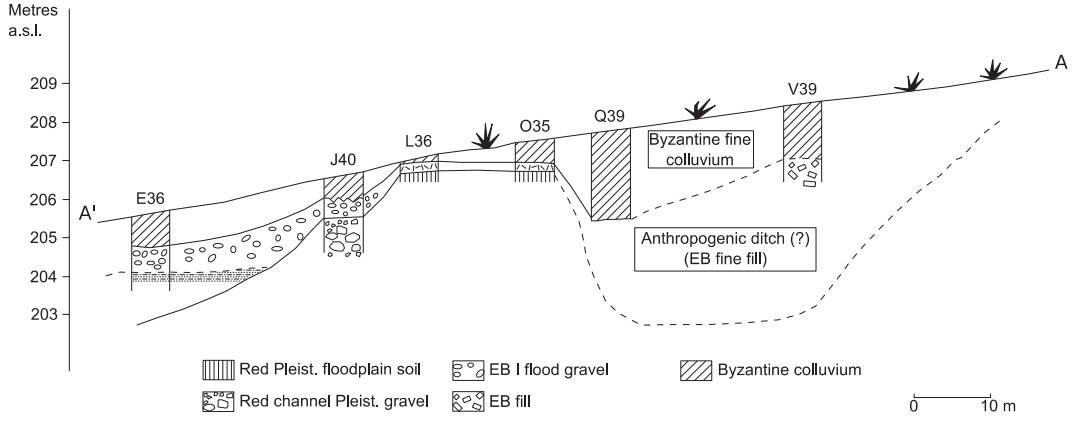

Fig. 5. Columnar sections east of Hartuv showing archaeological and geological deposits, and a possible anthropogenic feature.

Instead, their method of cooling is to seek shade and wallow in mud. In the southern Levant, a regional environment characterized by rapid climate change and erratic rainfall was locally buffered at Hartuv by marshy conditions from overbank flooding of the Nahal Soreq and possibly an anthropogenic feature that stored or diverted water. The particular hydrological conditions at Hartuv, which were distinct from other settlements in the Shephelah, would have provided pigs with an abundant water supply and plenty of mud in which to cool during the hot summer months.

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